static charges

all the shocking facts

Electrical components cannot deal especially well with static charges, which is a good reason to treat such charges carefully and with respect. In this article, we present a few practical tips for dealing with static charges, and in the process reveal why elephants should keep their trunks away from ICs.

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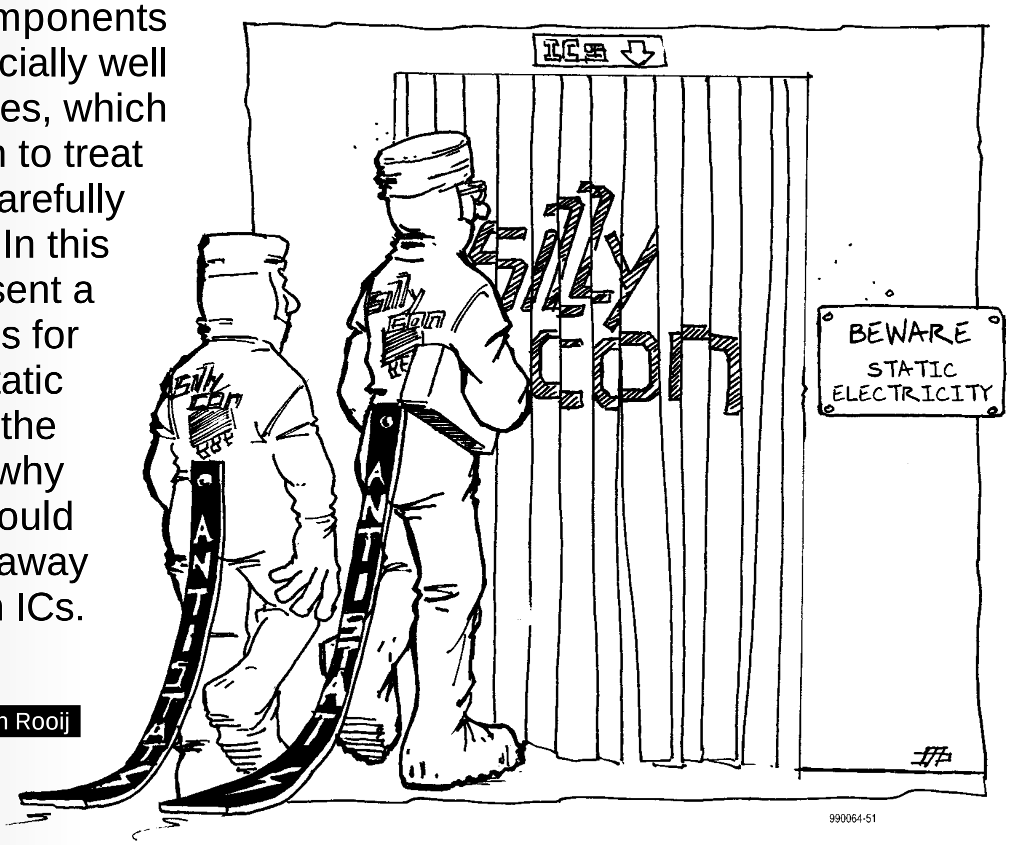

Commonly accepted ideas about static charges still exhibit a lot of misconceptions, and in this regard they are very similar to the ideas that arose with coming of the first (steam) trains in the last century. At that time, many persons (including famous scientists) thought that the human body would spontaneously disintegrate at speeds above 100 km/h. In the meantime, we know better. It is not the speed that matters, but the change in the speed. Simply driving a car at 100 km/h presents no problems, but if you run into a wall at this speed, your speed changes very quickly from 100 km/h to nothing, and you do in fact have a serious problem.

The situation with static electricity is similar. We have all at some time charged ourselves by petting a cat or walking over a synthetic carpet. The charge is built up gradually, so that you do not notice it. Only when you touch a doorknob, or another person that has a different charge, will you have a literally electrifying experience. When this happens, the charge changes rapidly, with a painful shock as a consequence. What you feel in this case is not the potential difference, but the discharge current that flows from your body. The larger this current is, the more painful the shock. By the way, you can keep the level of the discharge current low by holding one lead of a 10 kΩ or 100 kΩ resistor and touching the other lead first to the other object. This trick guarantees that you will not feel anything, even though the charges will still be equalized (it just takes a bit longer).

VULNERABLE COMPONENTS

Electronic components are even more sensitive to static (dis)charges than we humans. Most of them are so delicate that they can be irreparably damaged during charge equalization. Nowadays, we know that it does not matter if there is a charge of 1000 volts or more on a component, as long as the component's immediate surroundings have the same charge, so that there is no potential difference. If there is a potential difference, the internal insulation of the component can be damaged (punctured), or a current can flow to equalize the different charges. This current can also destroy the component.

Based on this knowledge, we can set up a sort of 'code of behaviour' for the safe handling of electronic components. What it all comes down to is that before you pick up a component, you must always make sure that there is no potential difference between your body and the component.

For example, suppose that you have bought new memory modules for your PC and you want to install them in the

PC. The bag in your pocket that contains the memory modules can have any arbitrary potential. This bag should be made of conductive plastic, which guarantees that there cannot be any potential difference between the individual memory modules or between the modules and the bag, so that the ICs are protected. Naturally, your own body also has an arbitrary potential with respect to the bag, and thus the first thing that you should do is to eliminate any potential difference between your body and the bag. If you are not afraid of a (small) shock, this is very simple: simply take hold of the bag with your fingers. Only after you have done this can you remove the modules from the bag without risk of static damage. Since there is no potential difference, you do not have to worry about touching the modules. In fact, you should touch them, since this creates a conductive path to your body, which prevents any new potential difference from arising. Once again, for good measure: *it is better to take the modules out of the bag with your bare hands than to use an insulated pair of pliers!*

The next step is to install the modules in the PC. Once again, the PC can also have an arbitrary potential with respect to your body. You should thus touch the enclosure of the PC with your other hand (not with the one holding the modules) on a conductive place, such as a bare screw (not the plastic or a painted part). This can also result in a brief, small shock, but the result is that there is now no potential difference between the bag containing the memory modules and the PC. This is because your body acts as a conductor that has eliminated the potential difference. Keep your one hand in contact with the PC while you use the other hand to install the memory modules in their sockets on the motherboard.

WHAT ABOUT EARTHING?

You may ask, is it not much better to first earth the modules? After all, the earth potential is zero, so nothing should go wrong if the modules are earthed. Let's look at what's involved here.

Just as you can feel completely comfortable at the top of the Eiffel tower (as long as you do not jump or fall), it does not matter to the component whether its potential is zero (earth) or some other value, as long as the potential is stable. Earth potential is thus actually not at all important, although it does form a handy reference. If you know in advance that the PC and the bag containing the modules are both at earth potential, then you do not need any measurements or other complicated procedures to be confident that there is no potential difference and thus no danger.

PEOPLE, NOT ELEPHANTS

Now comes the question, what can an IC actually tolerate? Let's consider the modern logic families. Manufacturers of ICs have noticed that people are careless. In spite of all the warnings, many ICs are damaged in daily life because people pick them up without taking special precautions. These manufacturers have thus provided their products with protective circuitry that can withstand an 'average' static discharge from the human body.

To give you an idea, a logic IC in the HC(T) family can tolerate voltages up to 2000 V (!). As a rule of thumb, we can assume that the human body has a capacitance of 100 to 150 pF with respect to its surroundings. This capacitance is discharged when a person touches an IC. If an elephant (which has a larger body and thus holds more charge in its body) were to pick up the same IC, the IC would not survive the contact. It would also not survive contact with you if your body were charged to more than 2000 V. However, practical experience has shown that the above-mentioned values are reasonable. The current that flows during a static discharge is not insignificant; we're talking about several hundred milliampères for a few microseconds!

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